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Real Time Computing Systems
EE 4770
Midterm Examination
15 March 1996, 8:40-9:30 CST

Problem 1 _____ (34 pts)

Problem 2 _____ (33 pts)

Problem 3 _____ (33 pts)

Alias _____

Exam Total _____ (100 pts)

Good Luck!

Problem 1: The temperature difference between *position 1* and *position 2* is to be found. Let $x_1 \in [290 \text{ K}, 310 \text{ K}]$ denote the temperature at position 1 and $x_2 \in [290 \text{ K}, 310 \text{ K}]$ denote the temperature at position 2. Temperature at position 1 is to be measured using an integrated temperature sensor with model function $H_{t\text{-ITS}}(x) = x \frac{\mu\text{A}}{\text{K}}$ and temperature at position 2 is to be measured using a thermistor with model function $H_{t\text{-thm}}(x) = R_0 e^{\beta/x}$, where $R_0 = 0.075 \Omega$ and $\beta = 3000 \text{ K}$.

(a) Show the linear form of the thermistor model function for the given temperature range in which the thermistor is placed in parallel with a linearizing resistor. (14 pts)

(b) Using the linear thermistor model function obtained above, design a circuit to convert the temperature difference $\Delta x = x_1 - x_2$ to voltage $H(\Delta x) = \Delta x \frac{\text{V}}{2\text{K}}$. Show all component and source values. (20 pts)

Problem 2: Design a circuit to convert force $x \in [0 \text{ N}, 0.3 \text{ N}]$ to a floating-point number $H(x) = x/\text{N}$ to be written into variable `force`. Use a large-displacement force sensor constructed from a non-ideal spring with response (mapping from force to amount of compression) $H_{\text{spring}}(x) = 7x \frac{\text{cm}}{\text{N}} - 10x^2 \frac{\text{cm}}{\text{N}^2}$ for $x \in [0 \text{ N}, 0.3 \text{ N}]$. Include an appropriate displacement sensor, show the function to be performed by the interface routine, and show all component and supply values. (33 pts)

Problem 3: Answer each of the three questions below. Be brief.

(a) Draw a diagram of an orifice plate flow sensor and explain how it works. Show any other sensors used with the orifice plate to convert the flow rate into an electrical quantity. The model function does not have to be shown. (11 pts)

(b) Explain how an ideal metal strain gauge works. In particular, explain how the electrical quantity changes with strain. (11 pts)

(c) A strain gauge attached to a beam has model function $H_t(x) = R_0(1 + 2x)$, where $R_0 = 100 \Omega$. Measurements are made at four times as indicated in the table below,

Time	Strain	Resistance/ Ω
t_1	1.3×10^{-5}	100.00237
t_2	1.3×10^{-5}	100.00257
t_3	5.1×10^{-5}	100.01000
t_4	1.3×10^{-5}	100.00297

where $t_1 < t_2 < t_3 < t_4$, strain remains constant from t_1 to t_2 , *strain* is measured using a calibrated device (not the strain gauge being tested), and *resistance* is the resistance of the strain gauge being tested. Find the model error, repeatability error, and stability error. Express each as a percent error and indicate which measurement times are used for each. (11 pts)